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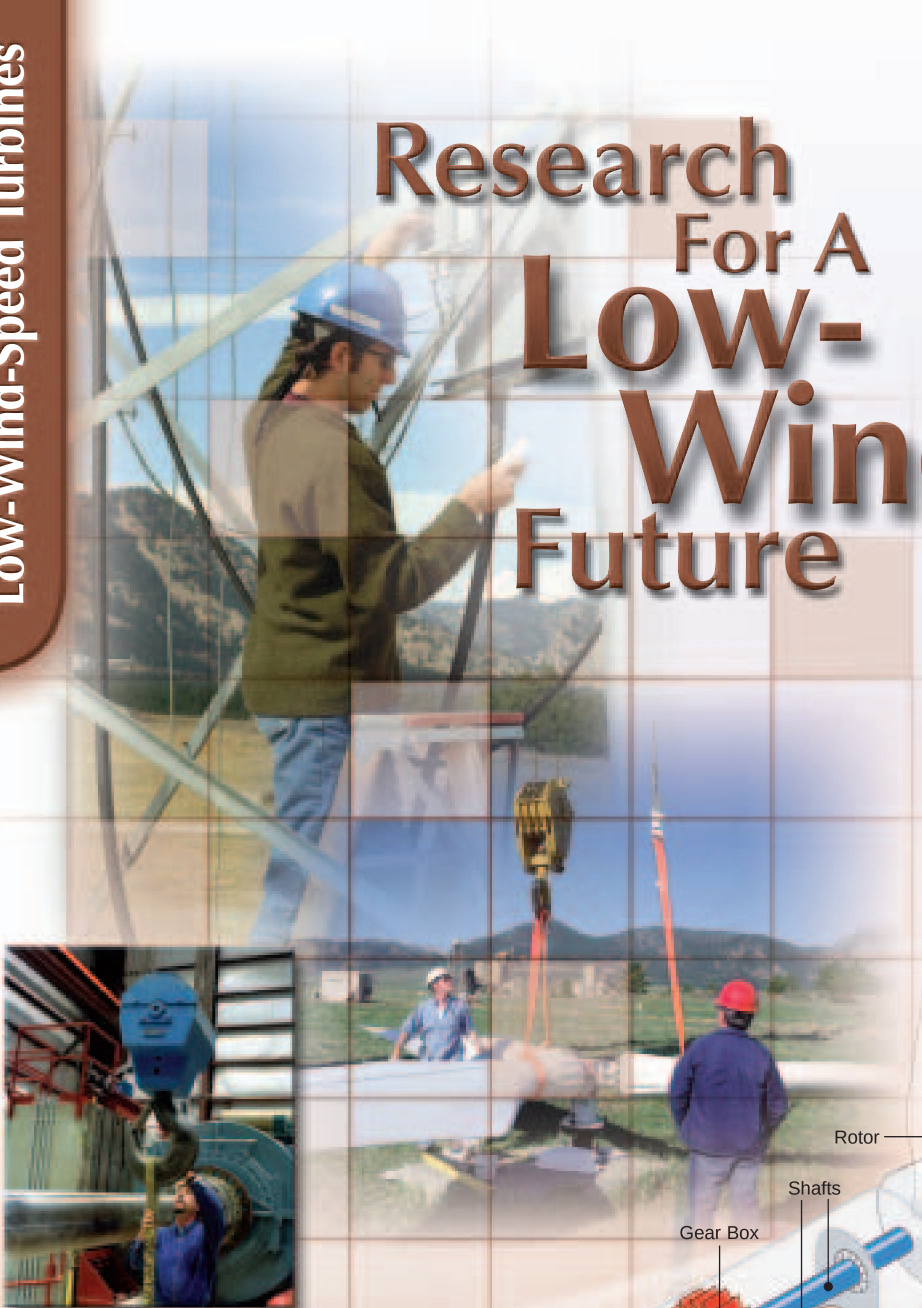
Research For A Low-Wind Future

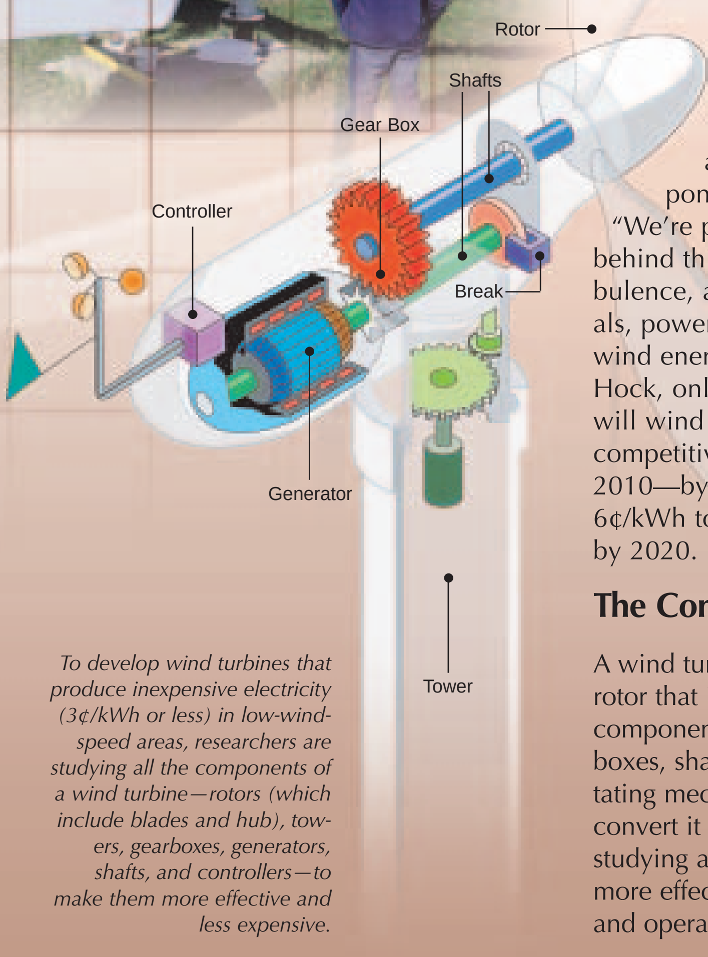


With rotor diameters longer than football fields, wind turbines of the future will stand on towers 400 feet high, operate even in low-wind areas, and have adapting blades that change shape according to wind speed and direction. As researchers develop the technology to grow turbines to gargantuan size, they also are working to shrink efficient designs—small turbines effective for homes or small businesses.

Already, wind power has made great leaps in technology and price competitiveness during the past two decades. Since the early 1980s, the cost of wind power has decreased from 80¢/kWh (in 2002 dollars) to about 4¢/kWh in high-wind-speed areas. And market use of wind power is growing at record speed—in the past two years alone, the amount of electric capacity produced by wind energy in the United States has almost doubled to 4,500 MW.

The challenge for wind power as we make the transition to our energy future is to hone the technology to be even more cost competitive and to operate under even lower wind speeds. By operating efficient turbines at low wind speeds—an average of 13.5 miles per hour annually versus the 15 miles per hour necessary now—20 times more land in the nation will be able to cost effectively access wind power.

With this goal in mind, the U.S. Department of Energy, NREL, and other wind research organizations are focusing on developing, testing, and lowering the costs of turbine components that operate in lower speeds. "We're putting our whole research program behind this—aerodynamics, understanding turbulence, advanced controls, advanced materials, power electronics," says NREL's Sue Hock, wind energy technology manager. According to Hock, only with continued low-wind research will wind power reach its goal of being cost competitive at low wind speeds with fuels by 2010—by bringing low-wind costs down from 6¢/kWh to 3¢/kWh, and even to below 2¢/kWh by 2020.



To develop wind turbines that produce inexpensive electricity (3¢/kWh or less) in low-wind-speed areas, researchers are studying all the components of a wind turbine—rotors (which include blades and hub), towers, gearboxes, generators, shafts, and controllers—to make them more effective and less expensive.

The Components of Wind Turbines

A wind turbine is composed of blades turning a rotor that is situated on top of a tower. Drivetrain components (which can include generators, gearboxes, shafts, and bearings) transfer the slow-rotating mechanical energy from the rotor and convert it to electrical energy. Researchers are studying all of these components to make them more effective and less expensive to manufacture and operate.

Modern wind turbines, such as these in Northern Colorado, generate competitive electricity in high-wind-speed areas. NREL's research is aimed at developing wind turbines that generate inexpensive electricity in low-wind-speed areas, opening up a vast wind resource for the nation.

One NREL program called WindPACT (Wind Partnerships for Advanced Component Technologies) combines laboratory research with applied, industry research to improve low-wind components. Promising research ideas and concepts generated in the laboratory are further developed and tested by a joint team of industry and laboratory researchers through WindPACT. Partnerships between new industry members and existing wind companies are encouraged, so the program attracts new organizations and ideas into the arena.

Making Towers Taller

One WindPACT study looks at how towers can be improved. Because wind speed increases with height above the ground, taller towers can find higher wind speeds even in lower-wind areas. But taller tower designs being tested now, between 200 and 300 feet, are still causing serious logistics problems during installation. The study found several alternative methods of constructing very tall towers, ranging from self-erecting concrete towers to telescoping tubes or jack-up devices. This work will form the foundation for further study by designers of low-wind technologies in the years ahead.

Sharpening Blades

Blade designs and manufacturing processes are also being honed for low-wind speeds. Transporting 300-foot blades across the country can be expensive and complicated—so researchers are looking at ways to set up mobile manufacturing "factories" at the site where the blades will be installed. WindPACT also found that new and lighter-weight materials will be necessary to grow blades to the larger sizes necessary. In addition to fiberglass (the material currently used) researchers are looking at carbon, which is stronger and lighter weight than fiberglass, or glass-carbon hybrids.

A blade for a 750-kW wind turbine is being fatigue tested at NREL's Industrial User Facility.

At NREL's Dynamometer Test Facility, a drivetrain for a 750-kW wind turbine undergoes tests to measure loading under realistic conditions and endurance tests to verify design life.

Testing the Wind

NREL's National Wind Technology Center (NWTC) south of Boulder, Colorado, houses the nation's most advanced, state-of-the-art facilities for testing wind energy systems. Eleven turbines—up to 600-kW capacity—tower over the plains, silhouetted by the foothills of the Rocky Mountains. Some of the wind turbines are prototypes of new designs, and others are baseline machines used for testing innovative components and control strategies.

Walt Musial, NREL's development testing team leader, says the wind site provides services to industry that they usually don't have access to: "This kind of testing and these kinds of facilities can be too expensive and too difficult to set up for one manufacturer." And, he says, the National Wind Technology Center's facilities are unique—the only blade-testing laboratory in North America that can test megawatt-scale blades and the only dynamometer facility that can do full-system wind turbine testing.

Through the installation and testing of these diverse kinds of turbines, researchers are learning how they operate and perform and how to enhance computer-aided analysis and design. During the next several years, NREL plans to install as many as 16 more experimental turbines at the center.

The site also hosts three specialized test facilities: The 10,000-square-foot Industrial User Facility tests the performance and structural reliability of individual wind turbine blades up to 85 feet long. This facility is the center for collaborative activities with the wind industry, and its unique building design enables several wind energy companies to simultaneously disassemble turbines, analyze the individual components, and modify the components while protecting proprietary information.

The Dynamometer Test Facility was constructed in response to industry requests. The facility gives engineers the ability to conduct lifetime endurance tests on a wide range of wind turbine drivetrains, gearboxes, brakes, control systems, and generators at various speeds, using low or high torque. A few months of testing on the dynamometer can simulate the equivalent of 30 years of use and a lifetime of braking cycles. Thus, engineers can determine which components are susceptible to wear and need redesigning to improve reliability and endurance of the components.

At the Hybrid Power Test Facility, researchers test existing systems and develop advanced controls for systems that use a variety of renewable and nonrenewable sources. The facility provides both real and simulated wind and photovoltaic energy sources, battery banks, and diesel generators, and allows testing under controlled combinations of solar and wind resources.